

## SIGNIFICANT POINTS

- High productivity growth is expected to keep employment growth low, but many openings will result from the need to replace workers who retire.
- Production workers, who account for over half of all jobs in the industry, increasingly need training beyond the high school level.
- Machinery manufacturing has some of the most highly skilled—and highly paid—production jobs in manufacturing.
- Job prospects should be favorable for skilled production workers.

### Nature of the Industry

The development and implementation of machinery was responsible for one of the great advances in human history, the industrial revolution. Machinery encompasses a vast range of products, ranging from huge industrial machines costing millions of dollars to the common lawn mower, but all machinery has one common defining feature: it either reduces or eliminates the amount of human work required to accomplish a task. Machinery plays a key role in the production of much of the country's goods and services because nearly every workplace in every industry uses some form of machinery. From the oil derrick that pumps out oil to the commercial refrigerator in use by your favorite restaurant, machinery is mainly responsible for the way we live today. Thus while most people never use or even see the machinery that makes their lifestyle possible, they use the products it makes every day.

The machinery manufacturing industry sector contains seven more detailed industry segments, as shown in table 1. Three of these make machinery designed for a particular industry—called special purpose machinery: agriculture, construction, and mining machinery manufacturing; industrial machinery manufacturing; and commercial and service machinery manufacturing. The other four segments make machinery used by many different industries—called general purpose machinery: ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing; metalworking machinery manufacturing; engine, turbine, and power transmission equipment manufacturing; and other general purpose machinery manufacturing.

The metalworking machinery industry makes machinery that forms metal when it is in its molten state, as well as machinery that cuts or shapes it when it is a solid. Although the growth of plastics has reduced the prevalence of metals, an enormous variety of products have some metal parts in them, all of which have to be precisely formed from the raw metal. The same properties that make metal a desirable component—its strength and durability—also make it a difficult material to form. The specialized drills, grinders, molds, presses, and rollers needed to form metal are made in this industry, as are the accessories used by these machines. Metalworking machinery manufacturing has a disproportionate share of the establishments that make up the machinery manufacturing industry because many are small, averaging fewer than 20 workers.

The agriculture, construction, and mining machinery manufacturing industry is made up of much larger establishments that produce some of the largest and most sophisticated machines, as well as some common household equipment. Examples of machines produced in this segment are farm combines, which are large self-propelled machines that both harvest and thresh grains at the same time, bulldozers and backhoes, equipment used for both surface and underground mining, and oil and gas field drilling machinery and derricks. This segment also makes lawnmowers, leaf blowers, and other lawn and garden outdoor power equipment intended for residential as well as commercial use.

The ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing industry makes machinery that provides climate control for residential and commercial buildings. In addition to heating and cooling equipment, this industry makes air purification equipment, which is increasingly common in new construction, as well as commercial refrigeration equipment, which is used primarily for food storage.

The machinery used by firms in the service sector of the economy is made by the commercial and service industry machinery manufacturing industry. Machinery produced here includes the commercial versions of common household appliances such as laundry equipment, coffee makers, microwave ovens, and vacuum cleaners. Other large components of this

**Table 1. Percent distribution of establishments and wage and salary employment in machinery manufacturing, by detailed industry, 2004**

Industry segment	Employment	Establishments
<b>Total</b> .....	100.0	100.0
Metalworking machinery manufacturing....	17.6	35.0
Agriculture, construction, and mining machinery manufacturing .....	17.0	10.7
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing .....	13.4	6.6
Industrial machinery manufacturing .....	10.6	13.3
Commercial and service industry manufacturing .....	10.1	9.2
Engine, turbine, and power transmission equipment manufacturing .....	8.2	3.4
Other general purpose machinery manufacturing .....	23.2	21.8

industry are manufacturers of automatic vending machines, non-electronic office machinery, such as typewriters and mail sorters, non-digital cameras, photocopiers, and machinery used to make optical lenses.

The industrial machinery manufacturing industry makes machinery used in the production of finished goods from raw materials. Wood, plastics, rubber, paper, textiles, food, glass, and oil are among the materials processed by the machinery made by this segment. It also makes machinery used in printing and bookbinding, as well as in the manufacturing of semiconductors and circuit boards.

The engine, turbine, and power transmission equipment manufacturing segment includes a variety of machines that transfer one type of work into another. Turbines use the energy from the motion of steam, gas, water, or wind to create mechanical power by turning a drive shaft, which with the use of gears, speed changers, clutches, drive chains, and pulleys—all also made in this segment—puts assembly lines and other industrial machinery in motion. Turbines also can create electrical power when attached to a generator. This industry segment also produces diesel and other internal combustion engines and their components that are used to power portable generators, air compressors, pumps and other equipment. Aircraft and motor vehicle engines are made by the aerospace product and parts manufacturing and motor vehicle and parts manufacturing industries, respectively, which appear elsewhere in the *Guide*.

The last segment—other general purpose machinery manufacturing—includes manufacturers of miscellaneous machines used primarily by manufacturing industries, including pumps and compressors, welding and soldering equipment, and packaging machinery. It also makes a variety of materials handling equipment used in manufacturing but also by a wide variety of industries, including industrial trucks and tractors, overhead cranes and hoists, conveyors, and many types of equipment that use hydraulics. This industry segment also manufactures other machinery that consumers are likely to encounter, such as scales and balances, power-driven handtools, and elevators, escalators, and moving walkways.

The machinery manufacturing industry also includes companies that specialize in making parts for larger manufacturers. Some of these parts manufacturers specialize in creating parts that require particular skill to make and then sell them to a wide variety of other manufacturers. Companies contract with these parts manufacturers because they can often provide parts cheaper than if they made them themselves. Cost is a primary selling point for these parts manufacturers and many of their parts are generally small and easy to transport, so these companies are particularly threatened by foreign competition.

The wide range of products made in the machinery manufacturing industry means that it includes establishments of all sizes. In general, however, the larger and more complicated the machinery is, the larger the manufacturing facility must be to produce it. Thus the agriculture, construction, and mining machinery and the ventilation, heating, air-conditioning, and commercial refrigeration equipment sectors tend to have large establishments, while the metalworking machinery segment has the most small ones.

Large firms involved in manufacturing machinery tend to have a multistage production process. Separate teams of individuals are responsible for the design and testing stages, the manufacture of parts, and the final assembly of the finished product. Workers

in different parts of the process still work closely together, however. Design offices are often located near the factory floor to facilitate interaction with production workers. Small establishments, in contrast, may have a handful of workers responsible for the entire production process.

The machinery manufacturing industry, like all U.S. manufacturers, continues to evolve to adopt new technologies and techniques to lower costs and raise the productivity of its workforce. Growing pressures from domestic and foreign competition are increasingly forcing machinery manufacturers to turn to high-technology production techniques, including robots, computers, and programmable equipment. Productivity gains resulting from these more efficient production techniques maximize the utilization of available equipment and workers, allowing reductions in the number of unskilled workers needed in the production process.

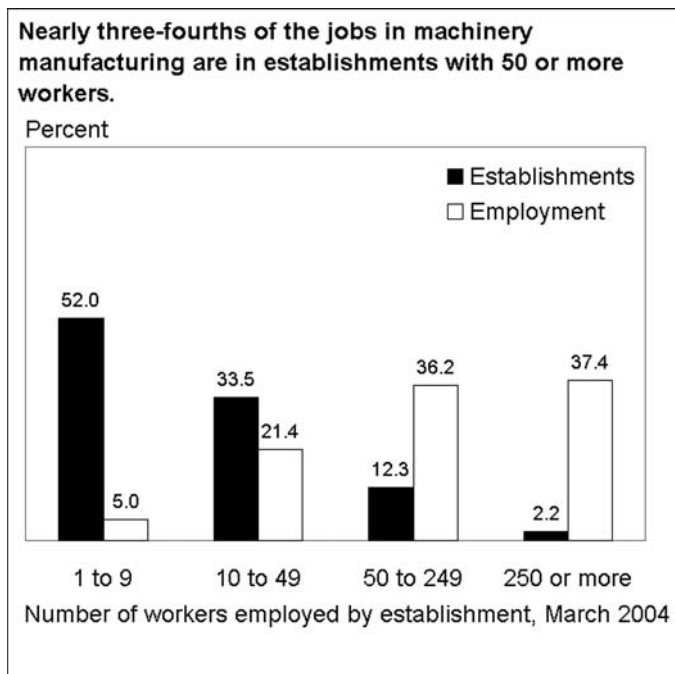
Pressures to reduce costs and maximize profits have also caused manufacturers in the industry to adopt new business practices. One common change is the contracting out of support functions, such as janitorial and security jobs, and increasingly some administrative services and warehouse and shipping jobs. Rather than employ workers directly for these jobs, a manufacturer will often contract with another company that specializes in providing these services. Not only does this reduce costs by forcing service providers to compete for the work, it allows the manufacturer to focus on what it does best—design and production. It also makes the manufacturer more flexible, allowing them to add and subtract contract workers more easily than they could hire and fire employees.

These changes have had a profound effect on the machinery manufacturing workforce. By automating many of the production processes and outsourcing many of the administrative and support functions, it has reduced the need for many less skilled workers and increased the skill level required for the remaining workers. These changes are allowing the industry to remain competitive and meet the demand for machinery that other industries rely on.

## **Working Conditions**

Production workers in the machinery manufacturing industry generally encounter conditions that are much improved from the past. New facilities in particular tend to be clean, well lighted, and temperature controlled. Noise can still be a factor, however, especially in larger production facilities. Most of the labor intensive work is now automated, though some heavy lifting may still be required of workers. Some workers may also have to work with oil and grease or chemicals that require special handling. Certain types of machinery also require particular care in their use. Nevertheless, injuries are rare when proper safety procedures are observed. In 2003, the rate of work related injuries and illnesses per 100 workers was 6.9, compared with 6.8 for all manufacturing industries. The rate for the private sector as a whole was 5.0.

Most workers in machinery manufacturing work 8 hour shifts, 5 days a week. Overtime can be common, though, especially during periods of peak demand. About 34 percent of workers averaged more than 40 hours a week in 2004. Some plants are capable of operating 24 hours a day, but some shifts are able to operate with a reduced workforce due to the automated nature of the production process.



## Employment

The machinery manufacturing industry provided 1.1 million wage and salary jobs in 2004. Employment was relatively evenly distributed among all segments of the industry (table 1). There were about 32,000 establishments in the industry; more than half employed fewer than 10 workers (chart 1). However, 37 percent of workers were employed in large establishments of 250 workers or more.

Although machinery manufacturing jobs are located throughout the country, certain States account for the greatest numbers of jobs. About a third of all jobs were located in the Midwestern States of Illinois, Indiana, Michigan, Ohio, and Wisconsin. Populous states such as California, Texas, New York, and Pennsylvania also had large numbers of jobs.

## Occupations in the Industry

It takes a wide variety of occupations to create and produce a machine (table 2). Before any work can begin on the production of a particular piece of machinery, an extensive process to create and test the design must be completed. This process can take up to several years, depending on the complexity of the machinery.

The design process takes place under the oversight of *engineering managers*. Much of the design work is done by *engineers*, who first develop a concept of what a new machine could do or how an existing one could be improved. Starting with this concept, they use computer modeling and simulating software to design the machine and test it for performance, cost, reliability, ease of use, and other factors important to both producers and consumers of the final product. *Mechanical engineers* design the moving parts of the machine, such as the gears, levers, and pistons in engine and hydraulic systems. They also direct the work of *mechanical engineering technicians*, who run tests on materials and parts before they are assembled into the final product. For machines with complicated electric or electronic systems, *electrical and electronics engineers* also assist in the design and testing process. *Industrial engineers*

**Table 2. Employment of wage and salary workers in machinery manufacturing, by occupation, 2004 and projected change, 2004-14**

(Employment in thousands)

Occupation	Employment, 2004		Percent change, 2004-14
	Number	Percent	
<b>Total, all occupations</b> .....	1,142	100.0	-12.8
<b>Management, business, and financial occupations</b> .....	112	9.8	-11.2
General operations managers .....	19	1.7	-13.2
Industrial production managers .....	12	1.0	-11.7
Buyers and purchasing agents .....	14	1.3	-11.8
<b>Professional and related occupations</b> .....	128	11.2	-7.2
Computer specialists .....	18	1.6	-8.6
Electrical and electronics engineers .....	10	0.9	-6.8
Industrial engineers .....	14	1.2	0.7
Mechanical engineers .....	30	2.6	-7.6
Mechanical drafters .....	15	1.3	-7.7
Engineering technicians, except drafters .....	20	1.8	-6.5
<b>Sales and related occupations</b> .....	40	3.5	-12.3
<b>Office and administrative support occupations</b> .....	127	11.1	-21.0
Bookkeeping, accounting, and auditing clerks .....	14	1.2	-20.7
Production, planning, and expediting clerks .....	12	1.1	-11.0
Shipping, receiving, and traffic clerks ....	18	1.6	-20.0
<b>Construction and extraction occupations</b> .....	19	1.7	-10.1
<b>Installation, maintenance, and repair occupations</b> .....	48	4.2	-11.3
Industrial machinery mechanics .....	11	0.9	-10.5
Maintenance and repair workers, general .....	17	1.5	-10.9
<b>Production occupations</b> .....	618	54.1	-12.8
First-line supervisors/managers of production and operating workers .....	41	3.6	-11.3
Assemblers and fabricators .....	193	17.0	-10.0
Computer-controlled machine tool operators .....	30	3.2	-10.9
Machine tool cutting setters, operators, and tenders, metal and pl .....	74	6.5	-22.8
Machinists .....	69	6.0	-11.6
Molders and molding machine setters, operators, and tenders, metal and plastic .....	12	1.0	-18.0
Multiple machine tool setters, operators, and tenders, metal and plastic .....	12	1.0	-11.8
Tool and die makers .....	29	2.5	-12.8
Welding, soldering, and brazing workers .....	64	5.6	-8.4
Inspectors, testers, sorters, samplers, and weighers .....	23	2.0	-16.4
<b>Transportation and material moving occupations</b> .....	42	3.7	-14.2
Laborers and material movers, hand .....	23	2.0	-17.6

Note: May not add to totals due to omission of occupations with small employment

determine how best to allocate the resources of the factory—both workers and equipment—for optimal production.

Once a design is finalized and testing complete, *mechanical drafters* create the plans that production workers use in the assembly of the machine. They provide specifications and diagrams for each part required, as well as assembly instructions for the final product.



The production process is directed by *industrial production managers*, who watch over all activities on the factory floor. Production workers account for over half of all jobs in the machinery manufacturing industry. *First-line supervisors and managers of production and operating workers* oversee all workers in the production process and ensure that equipment and supplies are available when needed. *Metal workers and plastic workers* create all the various parts that are needed in the production and assembly processes. As the production process becomes more automated, the jobs of most metal and plastic workers are more complex than in the past. Fewer workers are simply operating machines; most are now also responsible for programming and performing minor repairs on the machine tools.

Among the most skilled metal and plastic workers are *tool and die makers*, and machinery manufacturing has about 30 percent of the Nation's jobs for these workers. Tool and die makers create precision tools and machines, often using computer-aided design software, that are used to cut, shape, and form metal and other materials to exact specifications. Operating computer-controlled machine tools, they produce devices, such as jigs and fixtures, to hold metal while it is being worked on. They also produce gauges and other measuring devices, and dies that are used to shape the metal. These tools, dies, and jigs are used by *machine tool cutting setters, operators, and tenders, metal and plastic* who set-up and operate machines that make parts out of the raw materials. As most machines now operate automatically, the role of the machine tool operator is mainly to monitor the machine and perform minor repairs as needed.

*Computer control programmers and operators* manage the automatic metalworking machines that can mass produce individual parts. They also write programs based upon the specifications of the part that define what operation the machine should perform. *Machinists* produce precision parts that require particular skill or that are needed in quantities too small to require the use of automated machinery. *Welding, soldering, and brazing workers* operate machines that join two or more pieces of metal together; they may also perform welding work manually as well.

Once all of the parts have been made, it is the responsibility of *assemblers and fabricators* to put them all together to finish the product. Some assemblers specialize in one particular stage of the process, while others, such as *team assemblers*, work as a group and may contribute to an entire subassembly process. While there has been increased automation of the assembly process, many parts of the products still have to be put together and fastened by hand. When assembly is complete, *painting workers* apply paint or a protective coating to the exterior of the machine.

While quality control is a responsibility of all production workers, it is the primary focus of *inspectors, testers, samplers, and weighers*. They monitor the entire production stage, making sure that individual parts, as well as the finished product, meet the standards set by the company.

Other occupations in the industry provide support to production activities. *Industrial machinery installation, repair, and maintenance workers* are skilled mechanics that make sure that all the machines and other equipment used in the production process are regularly serviced and function properly. *Production, planning, and expediting clerks* produce records and reports related to various aspects of production, such as materials and parts used, products produced, and defects encountered. They

also make sure customer orders are completed, deliveries are scheduled, and shipments are made on time. *Purchasing agents* use the data provided by production, planning, and expediting clerks to procure supplies needed in production.

In addition to production-specific occupations, this industry has various managers, financial, and administrative support personnel to handle functions such as human relations, accounting, and general management. The sales function for many companies is increasingly important. *Sales representatives* and *sales engineers* often work together to market the company's machines to potential buyers, demonstrating how the machine may reduce costs or increase sales. They also explain how to operate the machine and answer buyer's questions. Sales engineers in particular use their technical background to advise clients on how the machine can best be applied in their individual circumstances and to suggest custom designs or modifications to the equipment as needed.

## Training and Advancement

The composition of the machinery manufacturing labor force continues to evolve as labor intensive tasks are automated, increasing the proportion of production work that requires additional skills. Nearly all jobs now require at least a high school diploma. Employers also want workers with good communication and problem solving skills, since new manufacturing processes, such as lean manufacturing, require workers to be able to perform many different tasks depending on where they are most needed. Strong basic mathematical skills are also essential.

Skilled production workers, such as tool and die makers and machinists, are usually hired on the basis of previous experience or after completion of a training program at a local college. Some companies also train workers entering the field in apprenticeship programs that can last between 1 and 5 years, depending on the specialty. These programs combine on-the-job training with classroom instruction, either within the company or at local technical schools. Topics covered in the apprenticeship include mechanical drawing, tool designing, programming of computer-controlled machines, blueprint reading, mathematics, hydraulics, and electronics. Workers also learn about company policies on quality control, safety, and communications.

Experienced workers can advance into the more highly skilled positions within their field or into supervisory positions. Because advancement is based on experience and merit, even those workers who enter in low skilled positions can advance to significantly higher skilled jobs if they work to improve their skills.

Management and professional occupations generally require a bachelor's degree in the particular field, though some management positions are filled by experienced production workers. Most engineer jobs in the industry require a degree in mechanical or electrical engineering or one of their specialties. Because engineers tend to be familiar with both design and production issues within the company, it is possible for them to advance into the upper levels of management.

## Outlook

Wage and salary employment in the machinery manufacturing industry is expected to decrease 13 percent over the 2004-14 period, compared with a 14 percent increase for all industries combined. As shown in table 3, all segments of the industry are expected to experience some employment declines.

**Table 3. Employment in machinery manufacturing by industry segment, 2004 and projected change, 2004-14**  
(Employment in thousands)

Industry segment	2004 Employment	2004-14 Percent change
<b>Machinery manufacturing, total</b> .....	1,142	-12.83
Metalworking machinery manufacturing .....	202	-16.21
Agriculture, construction, and mining machinery manufacturing .....	195	-2.56
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing .....	152	-8.79
Industrial machinery manufacturing .....	119	-12.53
Commercial and service industry machinery manufacturing .....	115	-26.02
Engine, turbine, and power transmission equipment manufacturing .....	93	-15.95
Other general purpose machinery manufacturing .....	266	-13.47

Despite the decline in employment projected for this sizeable industry, a significant numbers of job openings will become available because of the need to replace workers who retire or move to jobs outside of the industry. However, not all jobs that are vacated will be filled because attrition is one of the main ways that establishments reduce the number of employees. It is also a way the establishments upgrade the skill mix of their workforce. Machinery manufacturing establishments will be seeking to hire more highly skilled workers, especially persons with good basic educational skills that make the good candidates to be trained for the high skilled job of twenty-first century manufacturing.

The main factor affecting the level of employment in the machinery manufacturing industry is the high rate of productivity growth. Increases in productivity allow companies to produce more with the same number of workers. Even though output in machinery manufacturing is expected to increase significantly, firms will be able to meet the increase by the increasing productivity of existing workers, rather than by creating new jobs.

A second factor expected to cause employment declines in machinery manufacturing is growth of parts imports. This industry is less likely to lose a large part of its output to imports from other countries than some other manufacturing industries. The large size and complexity of many of the types of machinery made by this industry and the relatively skilled workforce it requires is an advantage that many manufacturing industries do not share. However, while most finished machines are made in the U.S., it is increasingly common for manufacturers to have some parts of the final product made in other countries and then shipped to the U.S. for final assembly. While still expected to account for only a small part of the total process, this increased offshoring of production will limit machinery manufacturing employment growth.

Demand for machinery is expected to remain strong. Machinery is important for all industries because it boosts their productivity, and advances in technology will make machinery even more efficient and thus more desirable. Demand for machinery is highly sensitive to cyclical swings in the economy, however, causing employment in machinery manufacturing to fluctuate. During periods of economic prosperity, companies invest in new equipment, such as machinery, in order to boost production. When economic growth slows, however, many

companies are reluctant to purchase new machinery. These changes in demand cause machinery manufacturers to replace fewer workers who leave or even lay off some workers.

Although overall employment in the machinery manufacturing industry is expected to decline, the outlook for occupations will vary; some will experience larger declines than others, while some will even experience growth instead. Increased automation and more efficient production processes will cause employment declines in assembler and fabricator occupations. Office and administrative support workers will also experience declines as a result of increased automation and contracting out. Employment in professional and management occupations will experience smaller declines relative to other occupations in the industry; engineers in particular will experience very good employment opportunities, as they are responsible for increasing innovation and competitiveness in the industry.

**Table 4. Average earnings of production or nonsupervisory workers in machinery manufacturing by industry segment, 2004**

Industry segment	Weekly	Hourly
<b>Total, private industry</b> .....	\$529	\$15.67
<b>Machinery manufacturing</b> .....	700	16.68
Metalworking machinery manufacturing .....	754	17.80
Agriculture, construction, and mining machinery manufacturing .....	639	15.16
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing .....	613	14.82
Commercial and service industry manufacturing .....	748	18.36
Industrial machinery manufacturing .....	728	17.37
Engine, turbine, and power transmission equipment manufacturing .....	762	18.04
Other general purpose machinery manufacturing .....	698	16.55

## Earnings

The earnings of workers in the machinery manufacturing industry are relatively high, primarily because of the high productivity of workers in this industry. Median weekly earnings in 2004 for production workers in machinery manufacturing were \$700, compared with \$659 for the manufacturing sector as a whole and \$529 for all industries. Earnings vary detailed industry segment of the industry (table 4). They also vary based upon a worker's particular occupation, experience, and the size of the company employing them. Earnings of the largest occupations in machinery manufacturing appear in table 5.

**Table 5. Median hourly earnings of the largest occupations in machinery manufacturing, May 2004**

Occupation	Machinery manufacturing	All industries
General and operations managers .....	\$45.38	\$37.22
Mechanical engineers .....	28.68	31.88
First-line supervisors/managers of production and operating workers .....	23.18	21.51
Tool and die makers .....	19.82	20.55
Machinists .....	16.70	16.33
Computer-controlled machine tool operators, metal and plastic .....	15.96	14.75
Inspectors, testers, sorters, samplers, and weighers .....	15.58	13.66
Welders, cutters, solderers, and brazers .....	14.55	14.72
Cutting, punching, and press machine setters, operators, and tenders, metal and plastic .....	13.04	12.45
Team assemblers .....	12.73	11.42

In 2004, about 11 percent of workers in machinery manufacturing were union members or were covered by union contracts, slightly less than the proportion for both the manufacturing industry as a whole and all industries combined. Major unions include the International Association of Machinists and Aerospace Workers of America, the International Brotherhood of Electrical Workers, and the United Automobile, Aerospace, and Agricultural Implement Workers of America.

### **Sources of Additional Information**

Information on employment and training opportunities in the machinery manufacturing industry is available from State employment service offices, employment offices of machinery manufacturing firms, and locals of the unions listed above.

Detailed information on most occupations in this industry, including the following, appears in the 2006-07 edition of the *Occupational Outlook Handbook*:

- Assemblers and fabricators
- Computer control programmers and operators
- Commercial and industrial designers
- Drafters
- Electricians
- Engineers
- Engineering technicians
- Industrial production managers
- Inspectors, testers, sorters, samplers, and weighers
- Machine setters, operators, and tenders—metal and plastic
- Machinists
- Material moving occupations
- Tool and die makers
- Welding, soldering, and brazing workers